A Directory Service for City Video Surveillance Systems

By
Sola Ajiboye, Chris Chatwin, Phil Birch, Rupert Young

@conference on Information Technologies, Systems and Networks.
Moldova, October 2017

University of Sussex

Surveillance Cameras in the UK

- **Video surveillance data is available in massive volumes** but they are locked away in private hands. It has been estimated that the number of CCTVs in the UK exceeds 6 million, however only 1.5% belong to government departments - http://www.bbc.co.uk/news/uk-30978995.

- **Video surveillance data is sensitive data** - the data protection act stipulates that owners of surveillance data must secure/protect the privacy of people in their data - https://www.gov.uk/data-protection/the-data-protection-act..

Surveillance strategy

- Establish a surveillance system as a component in the IoT-aware smart city.

- How can we integrate independent video surveillance systems, while each system remains independently owned, and managed?

- Organisation of video surveillance data in a hierarchical structure that emulates the world geographical hierarchy - **street, city, and country** - is beneficial

- This makes it possible to preserve the information relating to the identity and origin of surveillance data.

Resource Directory Definition (RD)

A resource directory (RD) is a network service (typically, a software component) that holds information about services and resources hosted on other network objects, with a view to lookup and discovery of the resource or service in response to a network request [1] [2].

A resource directory (RD) can support the indexing, cataloguing and administrating the surveillance data generated by cameras in a smart city

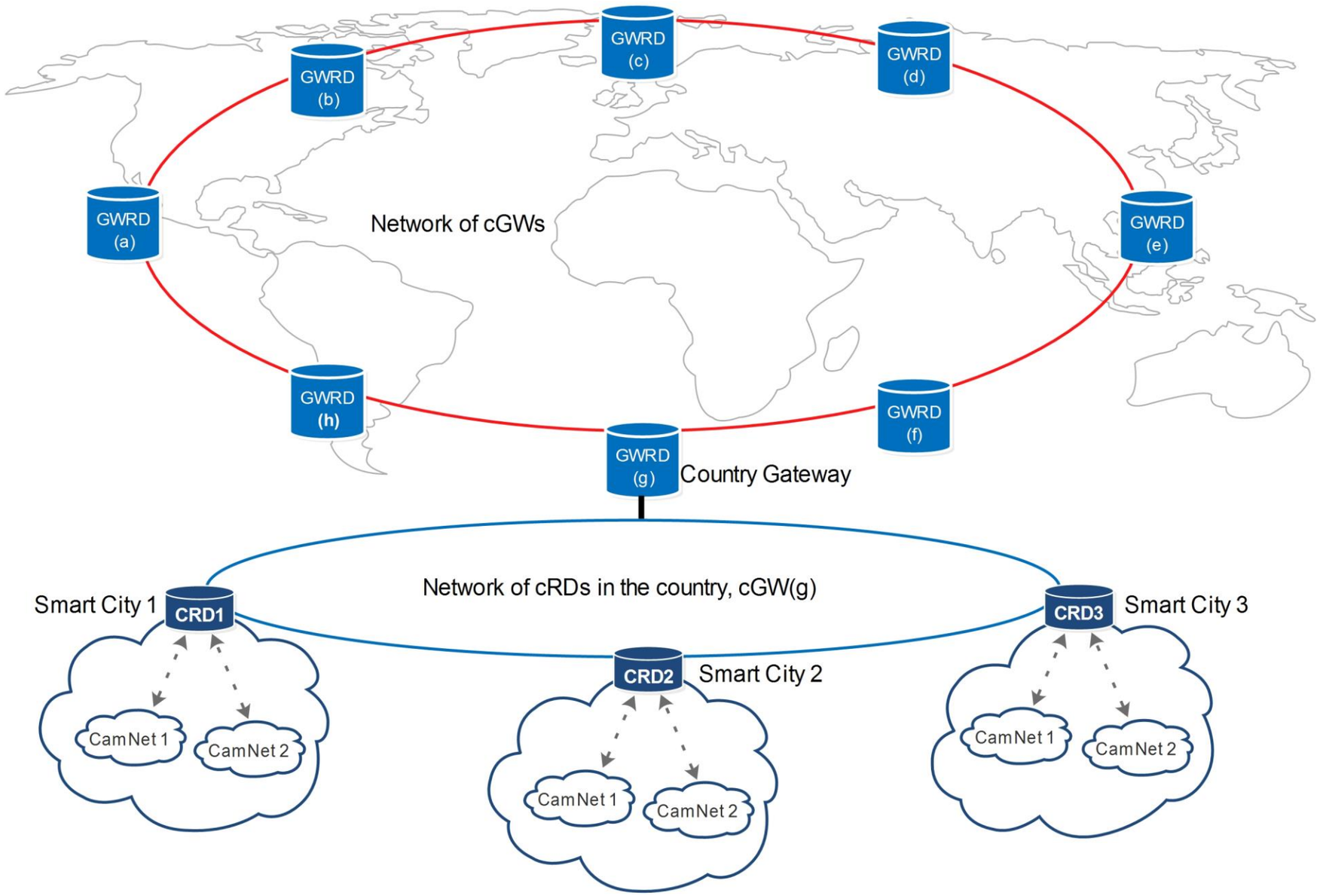
[1] S. Cirani, L. Davoli, G. Ferrari, R. Leone, P. Medagliani, M. Picone, and L. Veltri, “A Scalable and Self-Configuring Architecture for Service Discovery in the Internet of Things,” IEEE Internet Things J., vol. 1, no. 5, pp. 508–521, Oct. 2014.

[2] Shelby Z., K. Hartke, and C. Bormann, “The Constrained Application Protocol (CoAP),” RFC 7252 (Proposed Standard), Internet Engineering Task Force, 2014. [Online]. Available: http://tools.ietf.org/html/rfc7252. [Accessed: 29-Jan-2016].

Terminologies used in the subsequent slides…

- **CamNet: A camera or a ’group of cameras’.**
- **City Surveillance System (CiSS): The collection of the CamNets in the same city.**
- **Meta Data Server (MDS): Meta data repository**
- **City Resource Directory server (CRD): The resource directory server in a city.**
- **Gateway Resource Directory (GWRD): Country gateway that integrates into the global network.**
- **The Fused Video Surveillance Network (FVSN): The logical network of a surveillance system proposed in this research.**

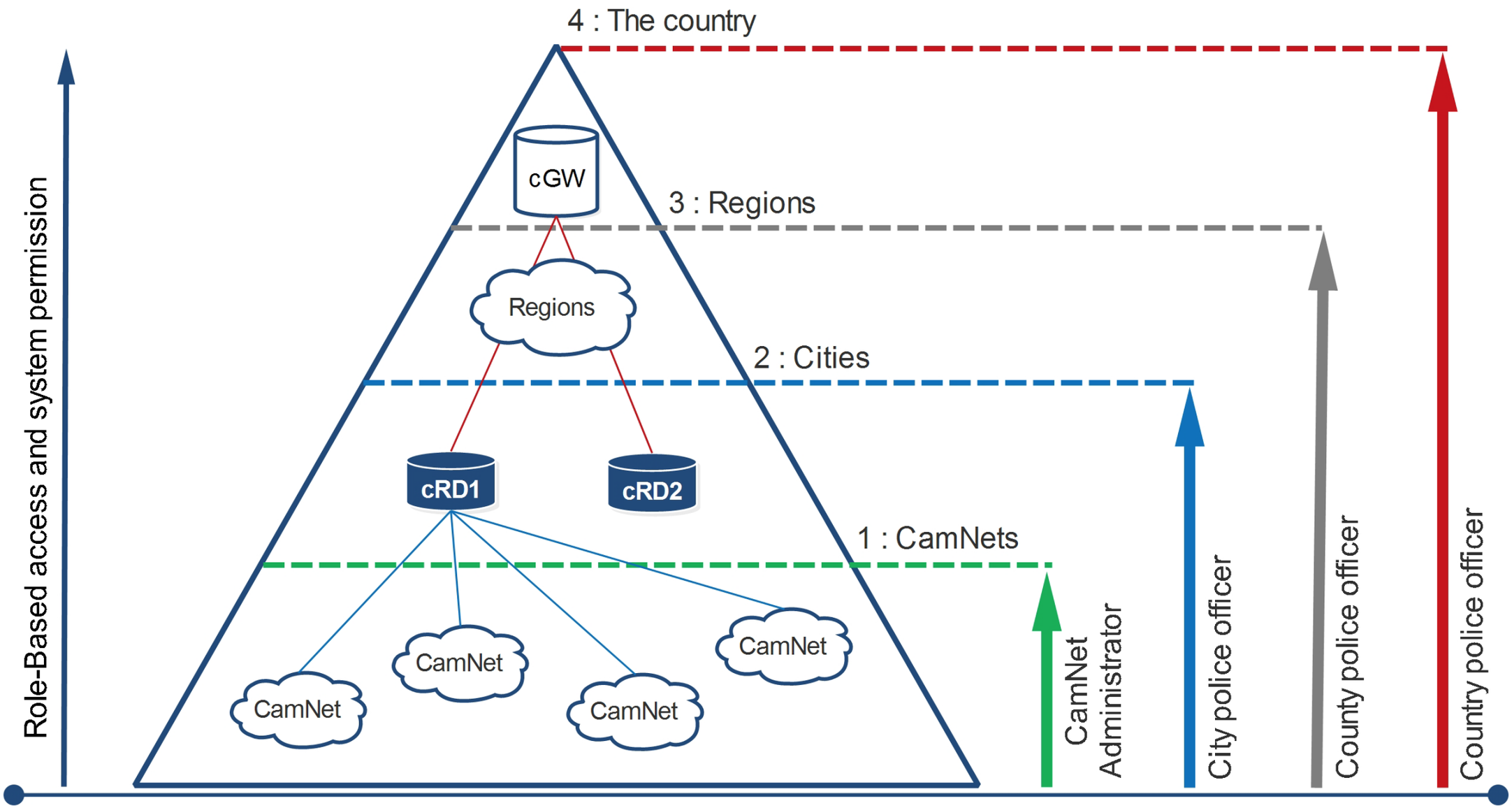
Fig.(1) Fused Video Surveillance Architecture (FVSA)



Shop, Mall, Street, Airport, Station

A collection of CamNets makes up a smart city surveillance system (CiSS),
A collection of CRDs is the country's surveillance network (CoSS)
While country-to-country integration is possible through the Gateway CRD (GWRD).
Resource Directory (RD)

Fig (2) The hierarchy



Country-level overview of the role-based access

The surveillance network in a country is organised into scopes emulating the hierarchies in the country’s geographic hierarchies.

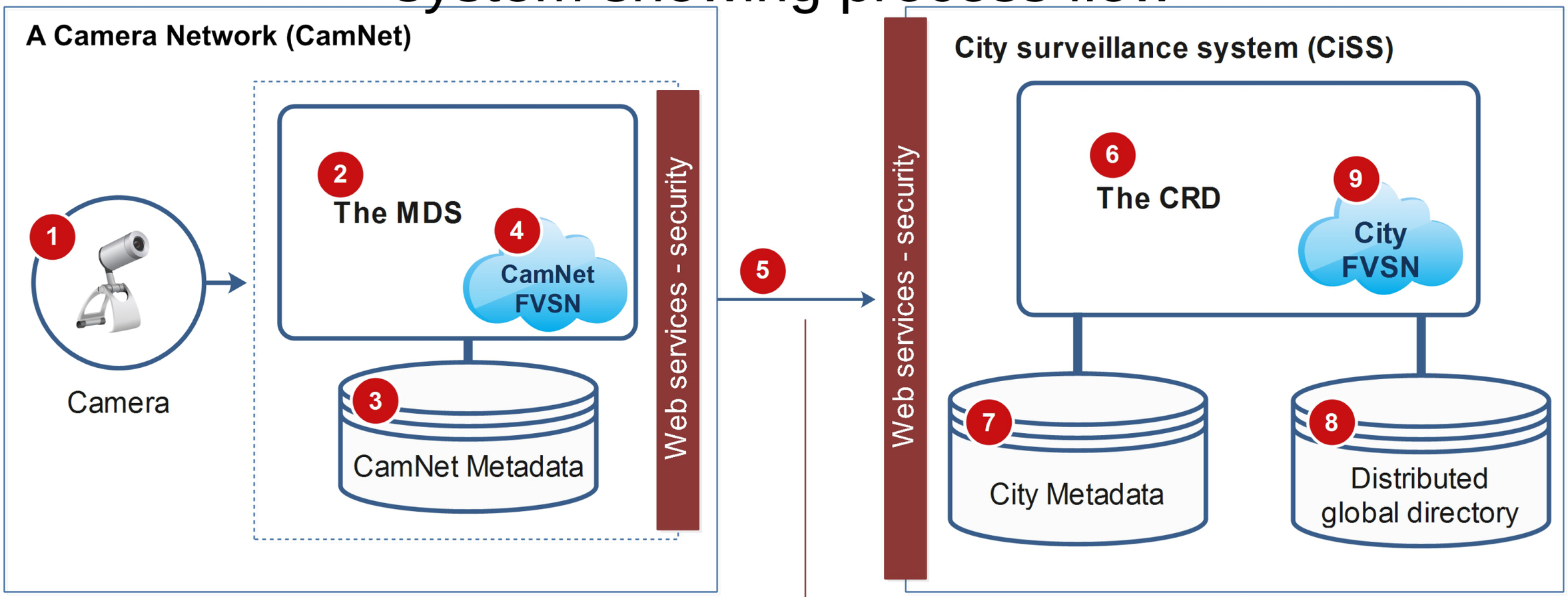
The Challenge

1. Is it technically achievable to analyse and explore a video surveillance system without the full system access to the surveillance network cameras and data?

2. How can we develop a resource directory (RD) server that is capable of indexing, cataloguing and administering the data collected across the city, at a public level?

3. The reliability of CRD’s is a critical issue that is explored herein

Fig 3: The high level conceptual view of the city surveillance system showing process flow



1. Generates metadata from cameras.
2. Cameras send metadata to the MDS.
3. MDS saves metadata.
3. MDS computes CamNet logical topology from the metadata.
5. MDS sends metadats to the CiSS.

6. Receives metadata from city CamNets
7. Integrates with CamNets across the city to compute the city FVSN.
8. Integrates with other CRDs across the country to create the country's network.
9. Computes and hosts the distributed global surveillance directory.

The effect of failed CRD's

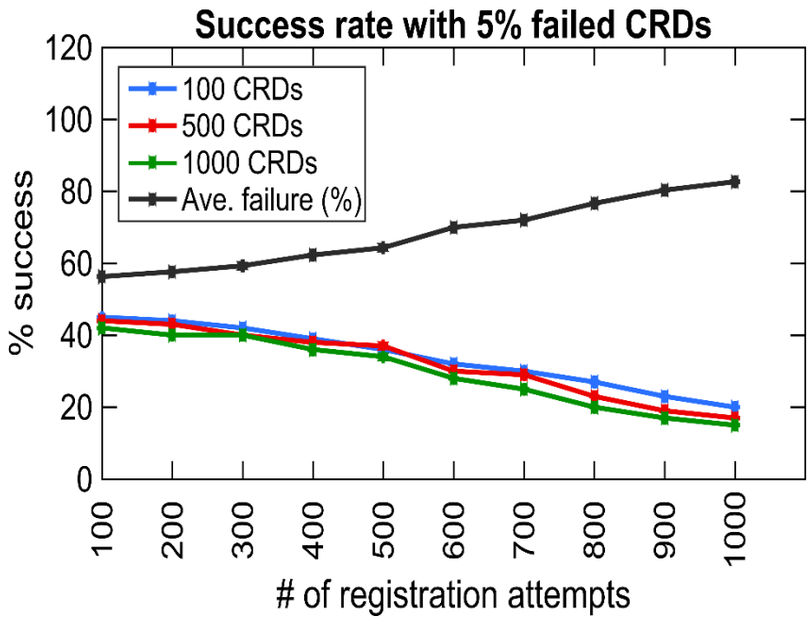
1. We set up CamNets that attempt to register with their local CRD from a pool of several CRDs. Once we have an operational system, we introduced 5% failed CRDs, then we increased the failure in increments of 5% up to 20%.

2. We observed that the failure rate rises with the increase in the number of registration attempts. It is also observed that reliability (that is, registration success rate) decreases as the number of request grows tending towards 0 reliability with 20% failed CRDs. See Figure (4)

3. Based on our observation of 0% reliability, we decided to add a routine to the registration process so that the CRDs first checks the availability of a known CRD before it forwards a message to it. If the recipient CRD acknowledges the request, then the message forwarding proceeds. However if the CRD is not found, a failed registration message is sent back to the CamNet and the CRD is removed from the network table. See Fig (5) for the results, success rate increased to 97%

Fig (4) Results

The figures below show the registration failure rate when 5% and 20% of CRDs in a city have failed but this unknown to the rest of the network. For the case of 20% failed nodes the success rate drops to zero after 600 registration attempts.



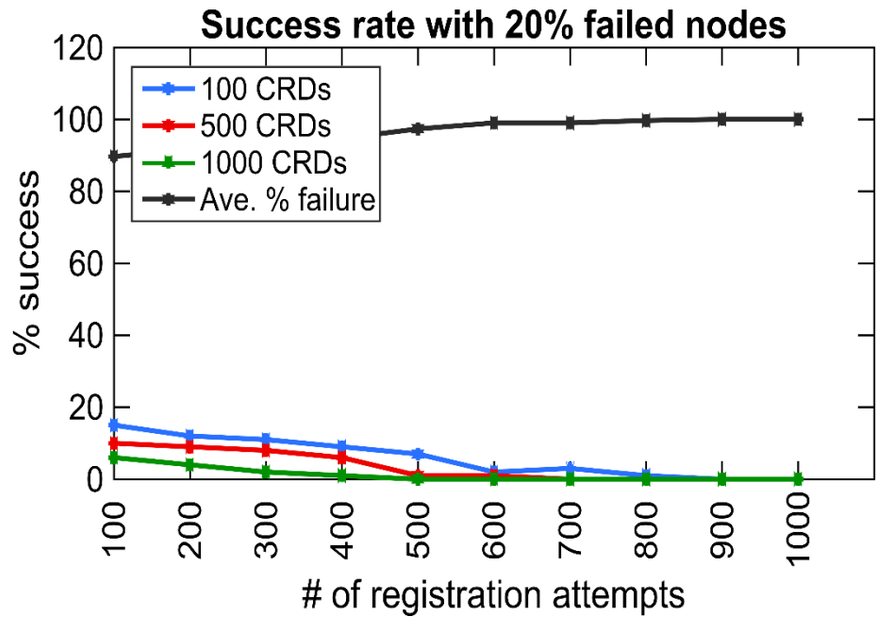
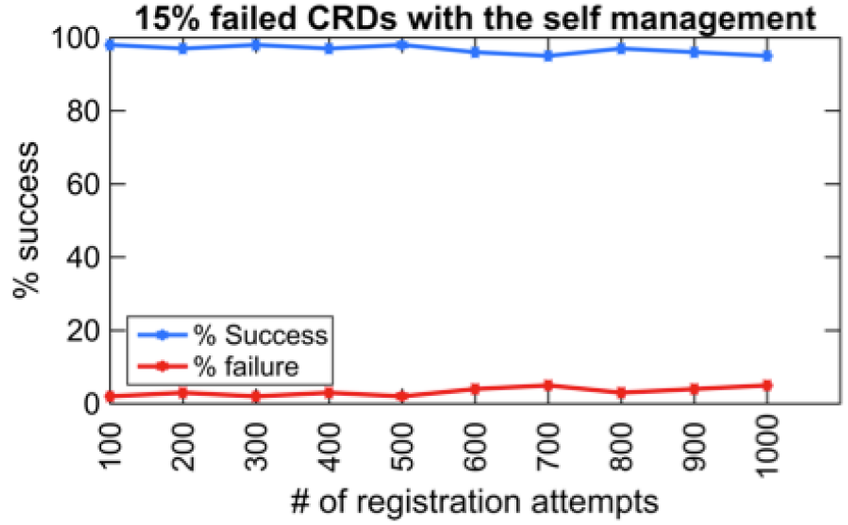
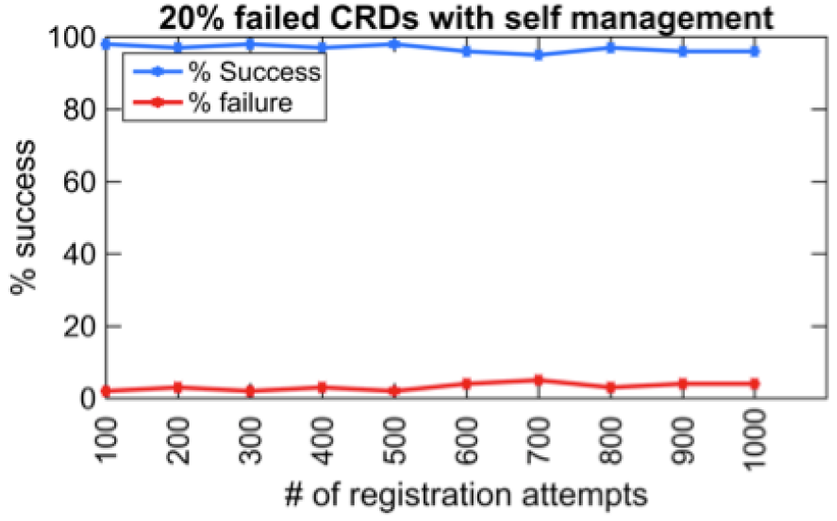


Fig (5) Results

The Figures below show the success rate of our solution when 15% and 20% CRDs in a city have failed but unknown to the rest of the network. The average success rate achieved 97%.



(a)



(b)

Success rate of the system under when varying percentage of the CRDs are not available.

Results

- We propose a citywide surveillance resource directory system to support and facilitate the cataloguing, accessing, managing and administration of the video surveillance networks.

- To demonstrate this work, we developed a simulation project in which resource directories designated for specific cities were used to administer local surveillance systems.

- We demonstrated how a surveillance system registers with only the appropriate CRD in its local city.

- We demonstrated how our solution manages failed nodes during the registration process of cameras joining the CRD.

Conclusion

- A city CRD is capable of providing information about any surveillance network in the city, through the local membership of the city's CamNets. In practice it can support the public safety departments in identifying and locating surveillance networks across the city without the need for physical street inspection.

- The experiment demonstrated that an unreachable CRD could result in inconsistent outcome so it is imperative to provide a solution. For example, when 90% of the total numbers of CRDs are accessible as in our experiment, the accuracy of registration is low (64% in our experiment).

- However with the introduction of the self-management solution, we recorded significant improvement to about 97%.

- We will further explore the possibility of perpetual 100% success rate in our future work by improving our self-management procedure.

THANK YOU